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About the journal

International Journal of BIM and Engineering Science (IJBES) is an international, peer reviewed journal, publishing high-quality, original research.

Aims & Scope

IJBES aims to provide researchers and experts with up-to-date research in BIM and its relation with Engineering Science, and to facilitate the global exchange and review of research, ideas and expertise among individuals in the scientific community.

IJBES publishes original peer-reviewed research papers, case studies, technical notes, book reviews, features, discussions and other contemporary articles that advance research and practice in **Building Information Modeling** in architectural, engineering, and construction management, advance integrated design and construction practices, project lifecycle management, and sustainable construction. The journal's scope covers all aspects of **architectural design, design management, construction/project management, engineering management of major infrastructure projects, and the operation and management of constructed facilities**. IJBES also addresses the **technological, process, economic/business, environmental/sustainability, political, and social/human developments that influence the construction project delivery process**.

IJBES strives to establish strong theoretical and empirical debates in the above areas of engineering, architecture, and construction research. Papers should be heavily integrated with the existing and current body of knowledge within the field and develop explicit and novel contributions. Acknowledging the global character of the field, we welcome papers on regional studies but encourage authors to position the work within the broader international context by reviewing and comparing findings from their regional study with studies conducted in other regions or countries whenever possible

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Editorial Word

It's a pleasure to present the first issue in the second volume for International Journal of BIM and Engineering Science (IJBES) in Jun 2019. IJBES is one of the scientific journals that BIMarabia s.r.o publish. BIMarabia is a publisher of peer-reviewed, open access academic journals and books. BIMarabia aims to provide researchers, professors and students with up-to-date research in BIM and its relation with Engineering Science, and to facilitate the global exchange and review of research, ideas and expertise among individuals in the scientific community. Established in 2015, BIMarabia has attracted over 20000 scientists worldwide. All content published by BIMarabia offers unrestricted access, and distribution, in any medium; provided the original work is correctly cited. We ensure the highest standards of peer-review for all manuscripts submitted for publication, thanks to the highly qualified scientists who are members of our journal's Editorial Board. BIMarabia delivers support throughout the complete publishing process in an efficient and effective manner.

Architectural, Engineering and Construction (AEC) industry has a giant influence in different nations' economic growth, however, it suffers from myriad problems. AEC industry projects faced issues such as being behind schedule, over budget, inferior quality, low productivity, without sustainability and more. The key players wandered about technology, methodology, or tools that can mitigate or solve these problems. Several researchers and professionals prove that Building Information Modelling (BIM) could help in solving the AEC industry problems. Despite there is no consensus about the definition of BIM; researchers and professionals recognize and appreciate the benefits of using BIM.

Therefore, IJBES concerns about BIM and the related and relevant engineering Science. The second volume, first issue, contains two articles. The first one deals with Methodology for BIM implementation in the Kingdom of Saudi Arabia. Whereas the second one discusses BIM Implementation Maturity Level and Proposed Approach for the Upgrade in Lithuania.

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Methodology for BIM implementation in the Kingdom of Saudi Arabia

Ashraf Elhendawi[1]*, Andrew Smith[2], Emad Elbeltagi[3]

Abstract

Purpose – The Architecture, Engineering, and Construction (AEC) industry is considered the most effective contributor to development in the Kingdom of Saudi Arabia (KSA). However, the AEC industry is facing myriad challenges due to the vast construction development required for the KSA 2030 vision. Developed countries are using Building Information Modeling (BIM) to mitigate these challenges and reap the benefits of implementing BIM to improve the performance of the AEC industry profoundly. However, BIM is currently rarely used in the KSA. This study aims to develop a methodology to implement BIM in the KSA by exploring stakeholders' perception of factors affecting the implementation. **Design/methodology/approach** – BIM users and non-users were surveyed by means of a questionnaire and structured interviews. The proposed methodology was validated through a further survey and structured interviews with BIM experts. **Findings** – This study proposes a six-step methodology to implement BIM namely; raising awareness; perceived benefits; AEC industry readiness, and organizations' capability; identifying the barriers; removing the barriers; and defining the key factors influencing the implementation. **Practical implications** – The proposed methodology is expected to assist project participants in KSA to implement BIM to solve current AEC industry issues, improve projects' performance and reap the benefits of implementing BIM. **Originality/value** – This study makes a crucial and novel contribution by providing a new methodology to implement BIM in KSA that motivates decision makers and project players to adopt and implement BIM in their projects. It paves the way to develop BIM guidance and strategies.

Keywords: Building Information Modelling, Saudi Arabia, AEC, Barriers, Benefits, Key Factors, implementation

1 Introduction

The AEC industry is considered the backbone of the economy for nations (Eastman, 1975), significantly impacting nations' growth (Giang & Pheng, 2011). The AEC industry in KSA is considered to be the second economic boom after the oil sector (Banawi, 2017). For the sake of improving the AEC industry's performance and productivity, researchers have claimed that implementing BIM is the best solution (Eastman, et al., 2011; McGraw-Hill, 2012; Matarneh & Hamed, 2017; Ahmed, et al., 2018).

The roots of BIM can be found in parametric modeling produced in the USA in the 1970s and that conducted in Europe in the 1980s. However, the AEC industry started to use BIM in its projects in the

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2000s. Since then, companies and governments around the world have attempted to adapt and reap BIM benefits (Eastman, et al., 2011).

Developed countries have recognized the benefits of BIM and considered BIM as the AEC's future language. For example, in the UK, the government mandated BIM in the AEC industry since 2016. Similarly, the USA and several European countries have mandated the use of BIM (Eadie, et al., 2013). However, developing countries are still in the early stages of exploring BIM and trying to find appropriate practical strategies for its implementation (Chan, 2014). There is no research providing a methodology to implement BIM in KSA, so this study aims to find a way to facilitate BIM implementation in KSA. The methodologies suggested for implementing BIM in the developed countries may not be suitable for implantation in KSA as the AEC industry there has different characteristics. Projects' parties in KSA consider that BIM benefits are not clear and believe that BIM implementation is very difficult due to the limited research on BIM in KSA (Almutiri, 2016).

2 Literature Review

Overview

BIM has been defined in various ways (Abbasnejad & Moud, 2013; Almutiri, 2016). For example, It has been defined as a group of interacting policies, software, processes and technologies, (Jung & Joo, 2011; Barlish & Sullivan, 2012) or as having a focus on applying information technology (IT) (Arayici & Aouad, 2010; Azhar, et al., 2015).

Whereas, Eastman, et al.(2011) defined BIM as a process that digitally manages the design, construction, and Operation and Maintenance. Azhar (2011) defined BIM as a virtual process that involves all aspects, disciplines, and systems of a facility within a single model that is shared with all stakeholders across the project lifecycle. Sabol (2008) defined BIM as a sophisticated software tool that helps to record information and to assist with its components.

Several researchers have cited the benefits of BIM as; leading to improved AEC industry performance and enhancing coordination and collaboration between various project parties. BIM is considered a revolutionary technology and management process, proposed as the potential solution to the current issues in the AEC industry (Liu, et al., 2010; Arayici, et al., 2011; Azhar, et al., 2015).

However, the main barriers that hinder BIM implementation can be summarized as; interoperability, functionality, unidentified BIM deliverables between parties, clients not requesting BIM, shortage in staff skilled in BIM, and the need for the 3D building product manufacturer (McGraw-Hill, 2012). This is in addition to, changing the organization of staff to suit particular skills (Eastman, et al., 2011), cost of implementation (software and training), lack of senior management support, scale of culture change required, lack of supply chain buy-in, ICT literacy and legal uncertainties (Eastman, et al., 2011; Eadie, et al., 2014; Shaban & Elhendawi, 2018).

Key factors influencing BIM implementation

Several researchers have argued that the main factors leveraging BIM implementation are recognising the benefits of BIM and driving forces (external forces) imposed from externals and/or the surrounding environment. For example, competitors use BIM, and internal readiness including IT sophistication and top management support (Liu, et al., 2010; Eadie, et al., 2013; Omar, 2015).

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The most important factors for increasing BIM benefits are: improved interoperability between software applications, improved BIM software functionality, more clearly-defined BIM deliverables between parties, more owners asking for BIM, more 3D building product manufacturer content, reduced cost of BIM software, more internal staff with BIM skills, more use of contracts to support BIM, more external firms with BIM skills and more entry-level staff with BIM skills (McGraw-Hill Construction, 2012).

Mehran (2015) argued that the main factors influencing BIM implementation are government support, BIM contract, standards, and protocols, development of a BIM performance matrix and industry collaboration. Moreover, Alhumayn, et al. (2017) suggested strategies for implementing BIM in KSA which include providing legislation and a supportive regulatory environment, government funding, educating key players and gaining the experience of advanced countries using BIM. However, Arayici, et al. (2011) suggested that approaches should be undertaken with a bottom-up approach rather than top-down. Omar (2015) and Alhumayn et al. (2017) claimed that to accelerate BIM implementation, government should take the upper hand (top-down approach) by facilitating smooth information flow. Table 1 illustrates the main factors influencing BIM implementation uncovered by the literature review.

Table 1: Key factors influencing the Adoption of BIM

No.	Key factors influencing BIM Adoption	Authors
External Push for Implementing BIM		
1	**Government pressure** (Intervention in mandating BIM)	(Eadie, et al., 2013; Omar, 2015; Willis & Regmi, 2016)
2	**Client pressure** and demand for application of BIM in their projects	(Saleh, 2015; Almutiri, 2016)
3	**Government support**	
Coordinated government support and leadership		(Smith, 2014; McPartland, 2017)
Developing industry-accepted BIM standards, best practices, and legal protocols		(Smith, 2014; Willis & Regmi, 2016; McPartland, 2017)
The government collaborates with the industry, professional bodies and education institutes to establish standards, guidance, to provide training to practitioners and future students and define levels of BIM working from reference in professional services agreement		(Chan, 2014; Smith, 2014; McPartland, 2017)
Set realistic goals, not to make things too complicated, plan for the worst, find a partner and provide high-end hardware resources and networking facilities to run BIM applications and tools efficiently		(McPartland, 2017)
A structured set of BIM competencies		(Succar, et al., 2013)
Having established industry-wide rules and protocols governing access and update.		(Willis & Regmi, 2016)
Developing suitable contractual arrangements		(Arayici, et al., 2011; Migilinskas, et al., 2013)
4-Other external pushes		
Raising awareness (promotion and awareness of BIM)		(Azhar, 2011; Almutiri, 2016; Gerges, M, et al., 2017)
Providing education at university level		(Tzonis, 2014; Omar, 2015; Almutiri, 2016)
Developing BIM data exchange standards, rules and regulations		(Chan, 2014; Mehran, 2016)
Providing guidance on use of BIM		(Gu & London, 2010; Mehran, 2016)
Contractual arrangements		(Deloitte, 2016; Mehran, 2016)
BIM required by other project parties		(Construction Work team, 2014; Saleh, 2015)
Competitive pressure		(Liu, et al., 2010; Eadie, et al., 2013)
Clients provide pilot project for BIM		(Saleh, 2015)

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Collaboration with universities (Research collaboration and curriculum design for students)	(Saleh, 2015; Almutiri, 2016)
Perceived benefits from BIM to client	(Gu & London, 2010; Azhar, 2011)
Availability of appropriate software and hardware tools	(Gu & London, 2010; Azhar, 2011)
Internal Push for Implementing BIM	
Top Management support	(Gerges, et al., 2016; McPartland, 2017)
Cultural change (resistance to change)	(Liu, et al., 2010; Gerges, et al., 2016)
Collaboration between all project participants	(Migilinskas, et al., 2013; Willis & Regmi, 2016)
Improving built output quality	(McCartney, 2010; Saleh, 2015)
Perceived benefits of BIM (concerted efforts to make clients demand BIM)	(Sebastian, 2011; Azhar, 2011; Omar, 2015)
Technical competence of staff	(Arayici, et al., 2009; McPartland, 2017)
Financial resources of organization	(Eastman, et al., 2011; Succar & Kassem, 2015; Omar, 2015)
The desire for innovation with competitive advantages and differentiation in the market.	(Liu, et al., 2010; Eadie, et al., 2013; Omar, 2015)
Improving the capacity to provide whole-life value to the client	(Omar, 2015; Gerges, et al., 2016)
Safety in the construction process (to reduce risk of accident)	(Omar, 2015; Saleh, 2015)
BIM training program for staff	(Smith, 2014; Gerges, et al., 2016; Gerges, M, et al., 2017)
Adapting existing workflows to lean oriented processes	(Arayici, et al., 2011; Eastman, et al., 2011)
Deciding which tool to use	(McPartland, 2017)
Applying successful change management strategies to diminish any potential resistance to change	(Arayici, et al., 2011; Eastman, et al., 2011)
Collaboration between all stakeholders	(Gerges, et al., 2016; Willis & Regmi, 2016)
Continuous investment in BIM	(Ding, et al., 2015; Saleh, 2015)
Projects complexity and profit declination	(Azhar, et al., 2015; Almutiri, 2016; Ball, 2017)
Approaches for adoption should be undertaken with a bottom-up approach to successful change management and deal with the resistance to change.	(Arayici, et al., 2011)

Every research argued different key factors may be they agree with one or more factor, but do not agree with all the same factors. Therefore, this study tries to examine all factors claimed by the previous researches and find further factors that have not been mentioned before.

Suggested strategies and methodologies for BIM implementation

Arayici et al. (2011) claimed that setting clear guidance and a methodology guarantees the achievement of the ultimate benefits of BIM. Several researchers have developed frameworks, models, and methodologies to implement BIM as follows:

The strategy of Olugboyega (2017) to create a BIM environment can be summarized as: (1) Acquiring BIM software technologies (according to the project goals) and BIM hardware, (2) Developing a BIM contents library, (3) Developing BIM standards, and (4) Setting up a BIM platform (interoperability tools, collaboration tools, integration tools, coordination/ clash detection tools and communication tools) according to the types of BIM software and hardware. Wang, et al. (2013) developed a BIM user acceptance model applying a technology acceptance model (TAM) (Figure 1).

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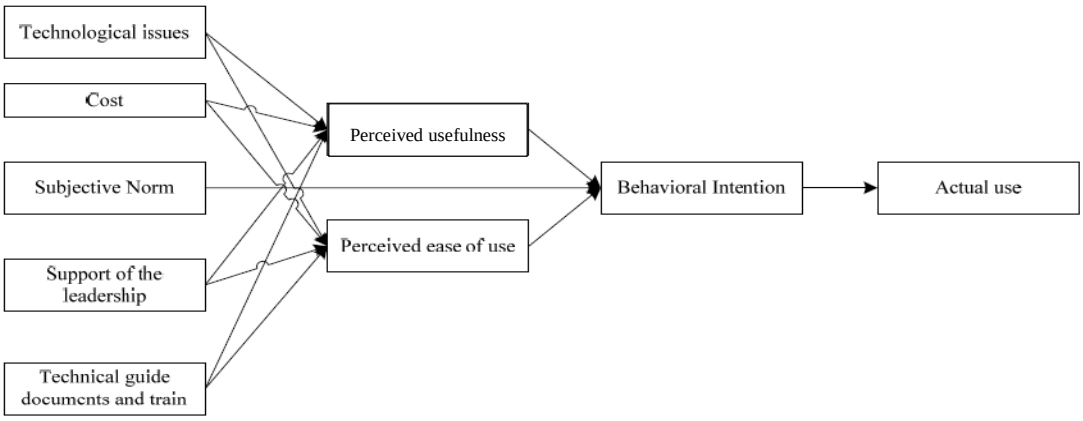

Figure 1: BIM Users Acceptance Model (Wang, et al., 2013)

Whereas, the EU BIM Task group suggested another strategic framework for BIM adoption in the public sector: growing capability, pilot projects, measuring and monitoring, case studies and embedding change (UK Construction Media, 2016). Furthermore, Jung and Joo (2011) proposed a BIM implementation framework as shown in Table 2.

Table 2: The BIM implementation framework (Jung & Joo, 2011)

Technical (T)	Perspective (P)	Construction Business Function (C)		
1.Data Property 2. Relation 3. Standards 4. Utilization	1. Industry 2. Organization 3. Project	1. R&D 2. General Admin. 3. Finance 4. HR. mgt. 5. Safety Mgt.	6. Quality Mgt. 7. Cost control 8. Contracting 9. Materials Mgt. 10. Scheduling	11. Estimating 12. Design 13. Sales 14. Planning

In spite of many approaches such as frameworks (Kekana, et al., 2014; Succar & Kassem, 2015) and technology adoption (Masood, et al., 2014; Arayici, et al., 2011) being proposed to support the implementation of BIM, the practical mechanism to adopt and implement BIM is still lacking. Perhaps, this can be justified by considering the status of BIM in both the developed countries (where BIM is mandated or nearly mandated) and developing countries (where BIM is still in its early stages), which show the need for a more practical and applied view of BIM rather than its potential benefits. Therefore, this research explores a practical methodology to implement BIM in KSA.

3 Research Methodology and Data Collection

3.1 Method of data collection

A mixed methodological approach is selected for this research consisting of three phases (Figure 2):

The first phase utilised an extensive literature review to build a deep understanding and to cover the research scope.

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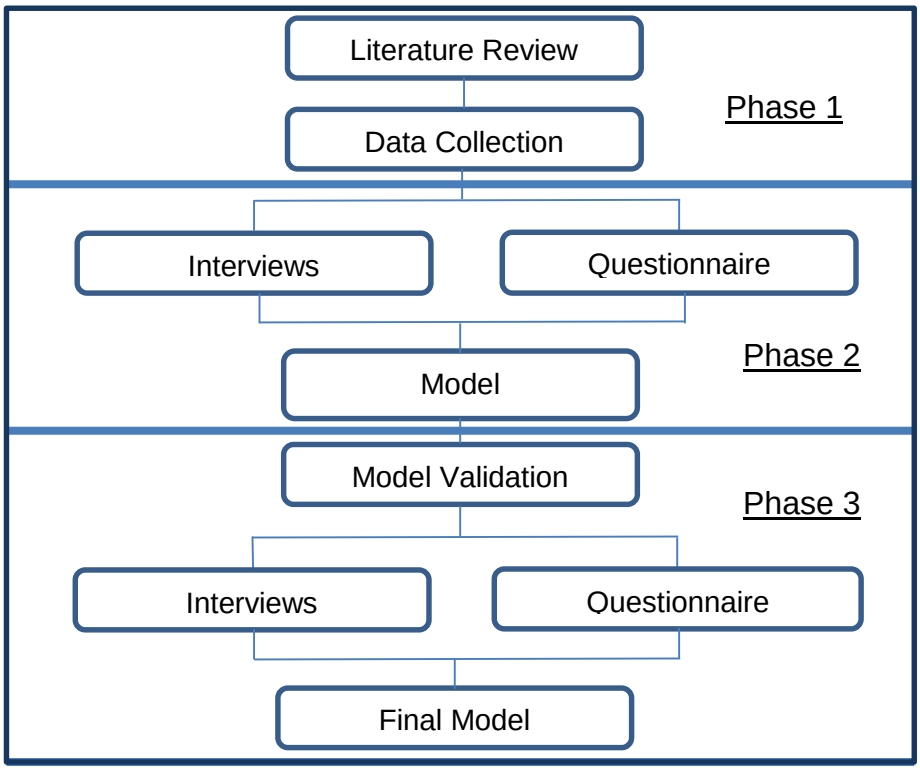

Figure 2: Research Methodology Flow Chart

The second phase consisted of two steps, a questionnaire and interviews to investigate BIM user and non-user perceptions about each step that produces the suggested methodology to implement BIM in KSA. Prior to finalizing the questionnaire, a pilot study was undertaken whereby 12 professionals with average experience of 8 years in the KSA AEC industry were interviewed. Six of the 12 professionals represented BIM users and the other 6 represented non-users. Those professionals were selected from local and multinational AEC organizations in the KSA market. The initial questionnaire was refined based on the feedback received from those professionals. Afterwards, the final questionnaire was accessible via the online survey platform "Google forms". This platform enabled easy and swift completion of the survey.

The structured questionnaire was distributed via mail and online. Also, the online questionnaire link was distributed to the organizations that are registered as members of the Saudi Commercial Chambers, which includes the entire KSA AEC industry organisations. Additionally, the Saudi Council of Engineers published the questionnaire in its monthly magazine.

The target population for this study included all professionals related to the KSA market whether they have a good knowledge and experience about BIM technology or not. It is almost impossible to calculate the exact number of the total targeted population as the number of engineers in Saudi Arabia according to the Saudi Council of Engineers is 230943 (Aleqt, 2017). Statistical equations were used to calculate the required sample size as follow (Eq. 1):

$$n = \frac{N}{1+N\,(c^2)} \quad (1)$$

C = margin of error, taken as 9% = 0.09.
N= Total population, taken as 231,000.

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n = Sample size.

Applying the equation: $n = \frac{231000}{1+231000\,(0.09^2)}$ =123.39 ≈124

The returned responses were 272 responses with 27 (9.92%) uncompleted responses. Each respondent was asked to rate to what extent he/she agreed/disagreed with each of the main factors influencing BIM implementation in KSA, on a five-point Likert scale ranging from 1 to 5, where 5 represents 'Strongly agree', and 1 represents "Strongly disagree".

Complying with the sample strategy, 124 Structured interviews were completed (62 are BIM professionals and the rest are not users) from different organizations disciplines and sizes (small, medium to large-sized).

The third phase consisted of two steps, an online questionnaire followed by interviews to validate the suggested BIM implementation methodology from only BIM users' perspectives. For rapid validation, an online questionnaire was sent to professional BIM experts who are working in KSA from different nationalities. The questionnaire was sent to 150 individuals, with 48 responses received (32%). The quantitative approach was considered a reliable methodology to test the hypotheses composed of variables derived from the first and the second phases (Naoum, 2012). As a second step of the third phase, fifty structured interviews as focus groups, who are BIM experts and BIM researchers, were organized.

3.2 Respondents General information

The received responses were 272. Of these responses, 63.1% indicated that they do not have enough knowledge to continue. However, 36.9% continued answering the questions. This suggests a lack of knowledge about BIM in KSA, in spite of literature (Farah, 2014) reporting a high level of awareness of BIM technology in KSA's AEC industry.

Table 3 shows the reasons that the non-BIM user respondents provided for not being interested in BIM. The largest percentage reported, "Don't Know what BIM is and it is out of my scope." Hence, this percentage implies raising BIM awareness could perhaps increase BIM adoption.

Table 3: Respondents' reasons for not having an interest in BIM

Reason	Frequency	Percentage
Don't know what BIM is	10	30.30%
It is out of my scope	10	30.30%
Have no time	4	12.12%
Not needed in my work	3	9.09%
Depend on customer	3	9.09%
CAD is enough	3	9.09%
Total	**33**	**100 %**

Also, 25.4% of the respondents represent public sector organizations and 74.6 % private sector organizations. This result may suggest that the public sector is less interested in BIM than the private sector. The highest percentage of respondents' specializations, 38.6%, are working in residential buildings projects Table 4.

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Table 4: Respondents' Organization specialization

Organization specialization	Responses	
	N	Percent
Residential	105	38.60
Commercial	94	34.56
Industrial	72	26.47
Health-care	53	19.48
Environmental	48	17.65
Infrastructure	104	38.24
Academic	62	22.79
Other Specializes	9	3.31

As shown in Table 5, the majority of respondents' organization size (64.0%) are over 200 employees. Also, a large percentage of respondents' organizations (35.52%) are working on large projects (501M SR -1Billion SR), as shown in Figure 3.

Table 5: Respondents' Organization size

Organization size (number of employees)	Frequency	Percent
1-30	33	12.1
31-60	33	12.1
61-100	12	4.4
101-200	20	7.4
Over 200 Employees	174	64.0
Total	272	100.0

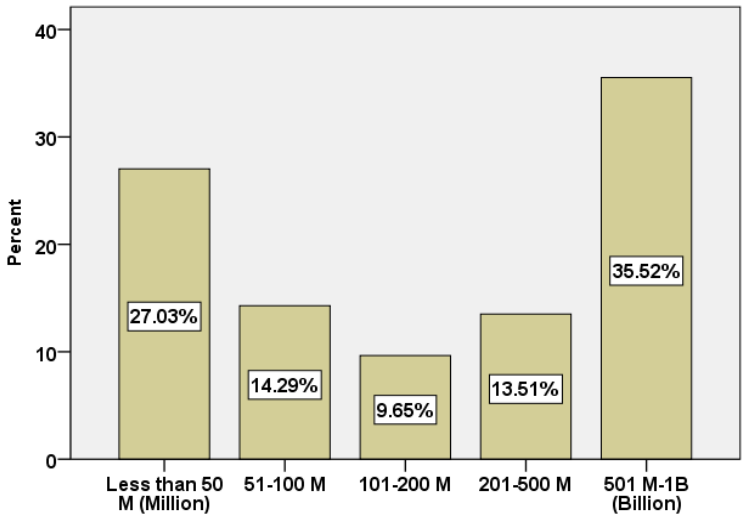

Figure 3: project budget

The largest percentage of the respondents (36.76%) are project/section manager (Figure 4). As shown in Figure 5, most respondents (29.36%) reported that they represent a Designer / Architect / Engineer.

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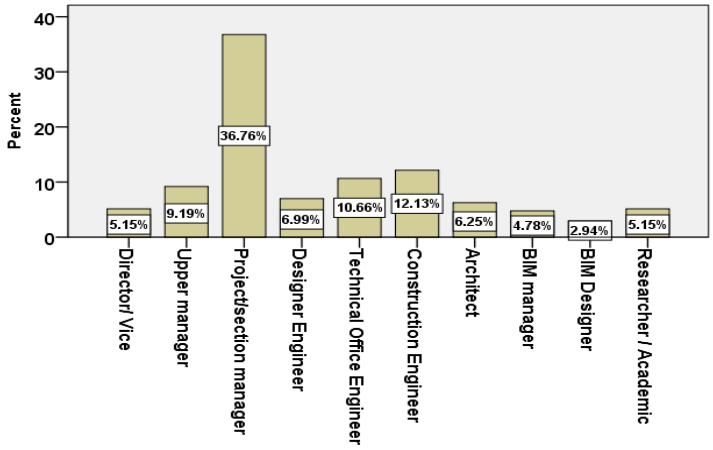

Figure 4: Respondents Position

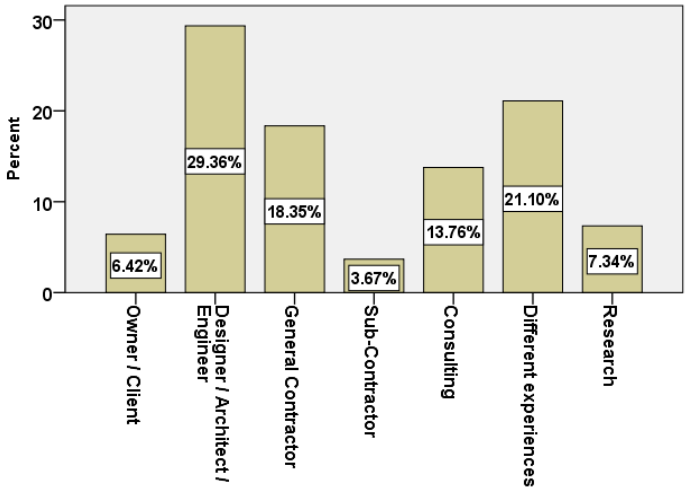

Figure 5: Respondents Role

Most of the respondents' educational level is B.Sc. (69.85%), while 23.16% and 6.99% of the respondents having Masters and PhD degrees, respectively. Most of the respondents (37%) have 5-10 years of experience as shown in Figure 6.

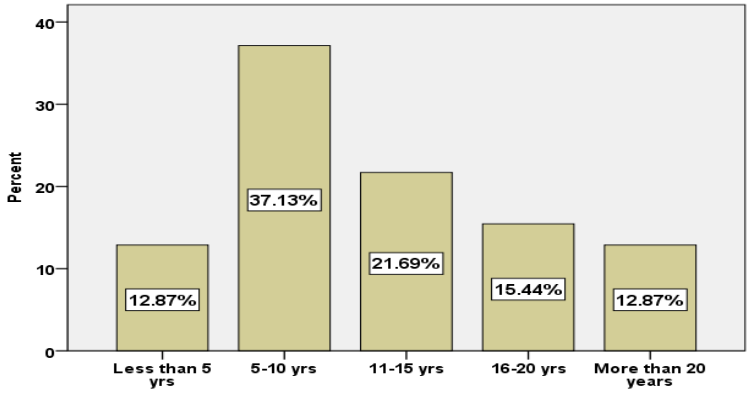

Figure 6: Respondents years of experience

The randomly tested sample covered all the KSA regions, however, the highest percentage (41.2%) is from Riyadh, followed by Makka al-Mukarama (13.2%), Eastern Province (6.3%), Madinah (4.8%),

Najran (2.9%), Tabuk (1.8%), Qassim (1.8%), Asir and Jazan (1.8%), Northern Borders (0.7%), Jawf (0.70%), Ha'il (0.4%), Bahah (0.4%).

4: Results analysis

4.1 Questionnaire

4.1.1 Key factors influencing BIM Implementation

The weighted mean as a descriptive statistical analysis which is based on the item's relative importance is used to rank the main factors influencing BIM adoption (BusinessDictionary, 2017). Table 6 illustrates respondents' ranking of the push factors for implementing BIM. Government, universities, and clients play a vital role to support and provide the requirements to expedite successful BIM implementation. This result conforms to the literature findings (Smith, 2014; McPartland, 2017).

Table 6: External Push Factors for Implementing BIM in KSA

Key Factors	Weighted mean	Std. Deviation	Ranking	The general trend
Providing guidance on use of BIM	4.01	1.088	1	Agree
Government support and pressure for the implementation of BIM	3.98	1.243	2	Agree
Providing education at university level	3.98	1.079	2	Agree
Developing BIM data exchange standards, rules and regulations	3.97	1.103	3	Agree
Perceived benefits from BIM provided to client	3.97	1.054	3	Agree
Collaboration with universities (Research collaboration and curriculum design for students)	3.96	1.088	4	Agree
BIM required by other project parties	3.96	1.075	4	Agree
Client pressure and demand for the application of BIM in their projects	3.95	1.160	5	Agree
Clients provide pilot project for BIM	3.93	1.037	6	Agree
Contractual arrangements	3.92	1.067	7	Agree
Promotion and awareness of BIM	3.90	1.062	8	Agree
Competitive pressure	3.84	1.101	9	Agree
Weighted mean	**3.9475**			**Agree**

Figure 7 shows respondents' factors representing the internal push for BIM implementation. Top management and organization capabilities are considered the main internal factors for BIM implementation. This result is compatible with the literature (Gerges, et al., 2016; Alhumayn, et al., 2017).

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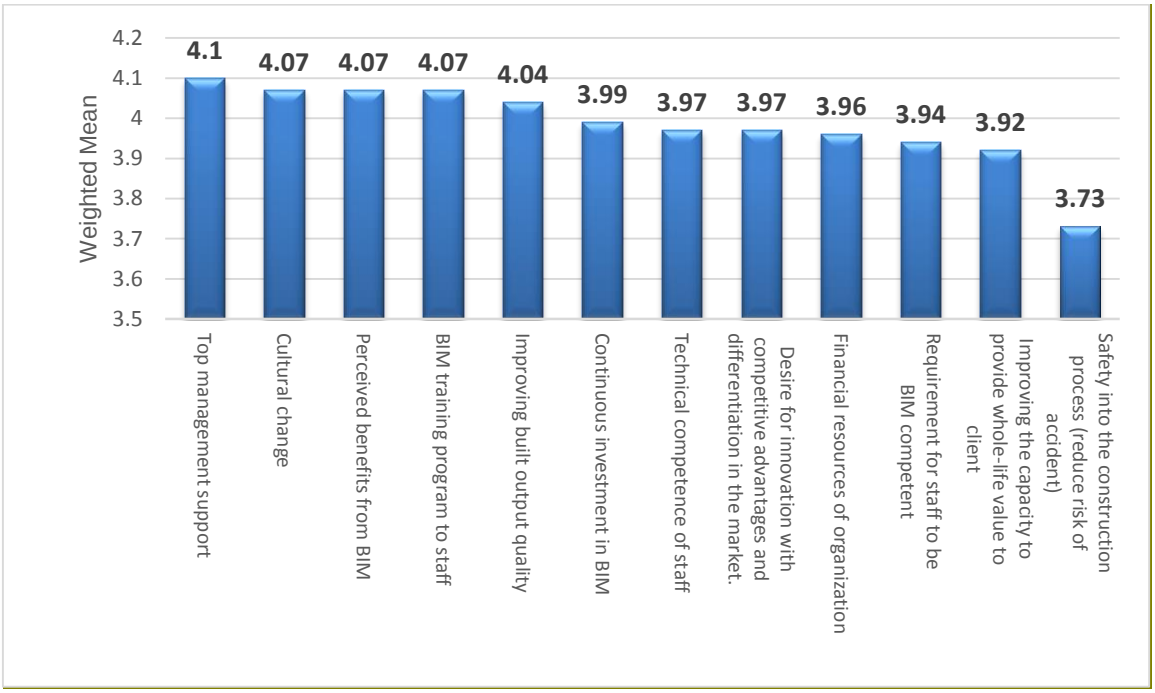

Figure 7: Internal Push Factors for Implementing BIM in KSA

Additionally, other internal push factors include: encouragement from all stakeholders and understanding how BIM will add value to the procurement process.

The average weighted mean for the importance of both the external push (3.9475) and the internal push factors (3.9858) to implement BIM are similar. As such, both types of factors are important to the adoption of BIM in KSA.

As presented in Table 7, non-BIM users' respondents intend to use BIM due to its perceived benefits, keep up with the latest technology; it is the future, improves their competences, and responses to the top management and the client demands**.**

Table 7: Coding the responses why BIM non-users intend to use

Reasons	Frequencies	Percent	Ranking
Perceived benefits	57	43.85%	1
It is the future	32	24.62%	2
Improve my self	31	23.85%	3
Client demand for it	6	4.62%	4
Top management mandates BIM	4	3.08%	5
Total	130	100 %	

4.2 Interviews

Interviews with 124 professionals (62 of them are BIM professionals and the other do not use BIM) were arranged to validate the results of the questionnaire. The interviewees suggested mixed approaches to expedite BIM implementation (Top-down and Bottom-up).

4.2.1 Key factors influencing BIM implementation

Interviewees suggested many factors representing a push for implementing BIM as follows:

- Focusing on the information (data) rather than the 3D model as globally, it is accepted that BIM is all about information. BIM is about converting design into reality
- The most important factors to implement BIM are client and consultant, BIM must be applied at the design stage, and the contractor cannot start working on BIM from scratch because of the long time required for modeling.
- Increasing awareness among projects' participants is highly demanded.
- The decision should come from top management to spread the knowledge and train users.
- Focusing on BIM success stories to guide the market.
- Governments need to support the BIM process if they want to help the market.
- The government should mandate BIM in KSA.
- There is a need for BIM training for the engineers (another discipline) to excel in their fields.
- All internal stakeholders should collaborate through BIM especially in the area of coordination.
- BIM needs more research for further development.

External Push

As per the interview with the experts, the factors for the external push to implement BIM are ranked in Table 8. These factors are the same as those obtained from the questionnaire survey, however, interviewees added availability of appropriate software and hardware.

Table 8: Coding of External Push Factors

External Push	Ranking
Providing guidance on use of BIM	1
Government support and pressure on the implementation of BIM	2
Providing education at university level	3
Developing BIM data exchange standards, rules and regulations	4
Perceived benefits from BIM to client	5
Collaboration with universities (Research collaboration and curriculum design for students)	6
BIM required by other project parties	7
Client pressure and demand for the application of BIM in their projects	8
Clients provide pilot project for BIM	9
Contractual arrangements	10
Promotion and awareness of BIM	11
Competitive pressure	12
Availability of appropriate software and hardware	13

Internal Push

As shown in Table 9, interviewees respectively ranked the factors for the internal push to implement BIM. Although, 12 of them are the same as the questionnaire result; they are in different order. Interviewees added collaboration among all project parties and projects complexity and profit declination as internal push factors.

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Table 9: Coding of Internal Push Factors

Internal push	Ranking
Top management support	1
Cultural change	2
Perceived benefits of BIM	3
BIM training program for staff	4
Improving built output quality	5
Continuous investment in BIM	6
The desire for innovation with competitive advantages and differentiation in the market.	7
Technical competence of staff	8
Financial resources of organization	9
Requirement for staff to be BIM competent	10
Improving the capacity to provide whole-life value to the client	11
Safety in the construction process (reduce risk of accident)	12
Collaboration among all project parties	13
Projects complexity and profit declination	14

5: Proposed Model for BIM Implementation:

The proposed model (Figure 8) is developed based on the extensive literature survey, and the recognized six factors influencing the implementation of BIM in the KSA AEC industry as a result of the questionnaire survey and the interview analysis.

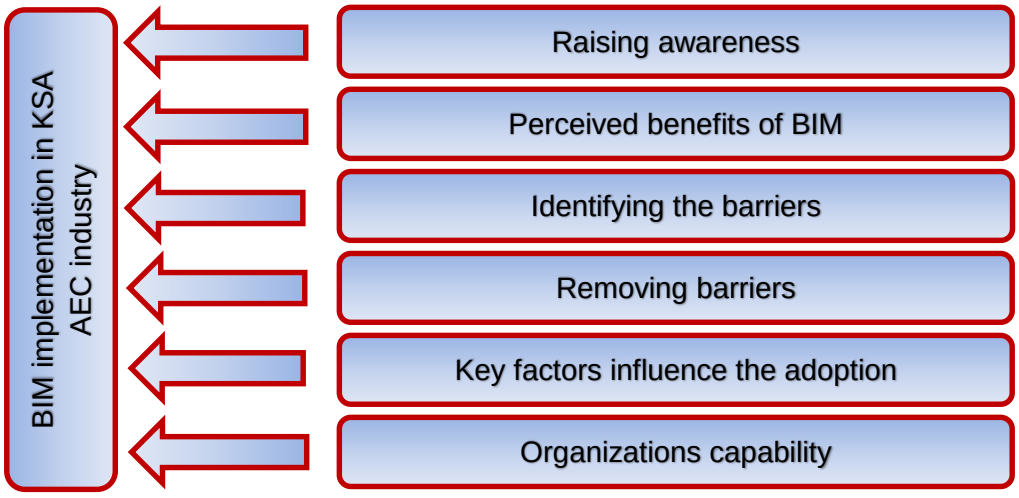

Figure 8: Conceptual Model for implementing BIM in KSA

The level of maturity readiness is investigated to implement and mandate BIM effectively considering the six factors. The proposed conceptual model is expected to assist the KSA AEC industry players to recognize the gaps that diminish the chances of successful implementation of BIM. The following subsections discuss the research hypothesis.

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Developing the hypotheses

1. Raising awareness (independent variable):

This factor aims to increase the KSA AEC industry players' knowledge about BIM, including BIM definition, BIM deliverables, BIM dimensions, maturity level, the comparison between BIM and CAD, BIM applications, integration with BIM, BIM status globally, lessons learned from countries using BIM, and how BIM works. The study checks the validity of a first hypothesis, *H1: The higher the appropriate awareness, the greatest are the opportunities for successful implementation of BIM.*

2. The perceived benefits of BIM (independent variable):

This factor refers to the anticipated benefits and advantages that the use of BIM can offer to the organization and the entire AEC industry. The perceived benefits of BIM are highly influencing the decision for the implementation of BIM. The study checks the validity of a second hypothesis, *H2: The higher the appropriate recognition of the benefits of BIM, the greatest are the opportunities for the successful implementation of BIM.*

3. Barriers to implement BIM (independent variable):

This factor refers to the obstacles that diminish the chances of the implementation of BIM. The study checks the correctness of the third hypothesis *H3: The higher the level of barriers, the lesser are the opportunities for the implementation of BIM*.

4. Removing the barriers to implement BIM (independent variable):

This refers to removing the obstacles that diminish the chances of the implementation of BIM. The study checks the correctness of the fourth hypothesis *H4: The more the barriers to be removed, the higher the opportunities for successful BIM implementation.*

5. Key factors influence BIM adoption (independent variable):

This includes two main categories:

- The main driving forces: or the external factors which are recognized as the external pressure from authorities either the government or the client, to impose the utilization and mandate of BIM as a compulsory requirement.
- Assistant factors: or the internal factors, including individuals, organizations and software suppliers.

The study checks the correctness of the fifth hypothesis *H5: The more the adoption of factors influencing BIM, the greater are the opportunities for the implementation of BIM*.

6. The KSA AEC industry readiness and organisations capability (independent variable):

This refers to the readiness of the organisations and the industry for BIM implementation. The study checks the correctness of the sixth hypothesis *H6: The higher the internal readiness to adopt the change to BIM, the greater are the opportunities for successful implementation of BIM*.

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7. Implementation of BIM in the KSA AEC industry (dependent variable):

This dependent variable is directly influenced by the six independent variables as suggested in the conceptual model and the proposed hypotheses.

6. Model Validation

6.1 Questionnaire:

The respondents ordered the six independent variables which impact the dependent variable (implementing BIM in KSA AEC industry), as shown in Figure 9. The weighted mean for 5 variables are greater than four, while the sixth is almost equal to 4 (3.94), so all research hypotheses are accepted (Boone & Boone, 2012).

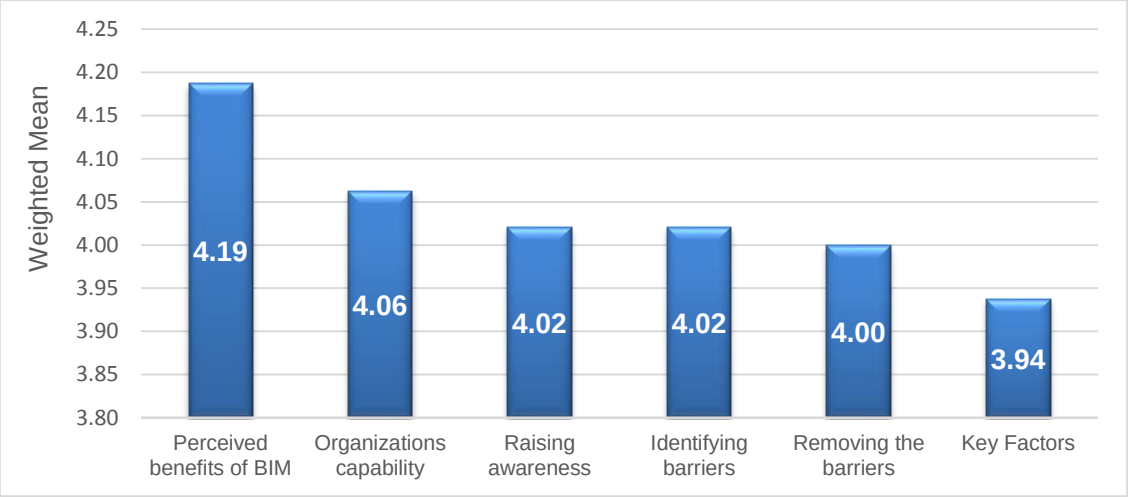

Figure 9: independent variables impact the BIM implementation in KSA

6.2 Interviews:

The interviewees ordered the independent variables which impact the BIM implementation in KSA, as shown in Table 10.

Table 10: Ranking of variables impact BIM implementation

Independent variable	Ranking
Raising awareness	1
Perceived benefits of BIM	2
Organisation capability	3
Identifying barriers	4
Removing the barriers	5
Key factors influence the adoption	6

Most of the interviewees agreed with the steps of the suggested methodology, and they confirmed those are enough, but slight conflicts have been uncovered regarding the order of the steps. Moreover, an interviewee reported that "factors influencing the implementation are possibly the road that you travel on - not just a point. The factors will be there from the very beginning - attitudes/beliefs/money/resources/leadership etc. will change as the journey continues. Perhaps not a path, but a cyclical process."

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Whereas, another said "*Define desired BIM outcomes, and think what you want to achieve once it's all implemented*." While, other interviewees said that "*The perceived benefits of BIM should be the actual benefits of BIM". The perception happens in the mind of the person who has never used BIM in the construction process before. This is a transition from 2D thinking in the construction process to 3D+, visualization and simulation of a true digital construction asset to be used in conjunction with the projects life cycle plan. It's like telling someone who has been doing something their whole life that their industry has become a tech industry and its benefits are the base that the next generations of construction will have a foundation on. Custom manufacturing using 3D printing and milling, component and modular construction, you can't use these if you do not use BIM*."

Additionally, another reported that "*to implement BIM in KSA, the first step should be raising awareness, secondly, convince the key decision makers about perceived benefits of BIM, then make a feasibility study to prove the profit and BIM benefits acquired from its implementation. The last step is to develop a strategic plan with consideration of experiences and examples of successful application of BIM*."

However, interviewees agreed with the methodology, they suggested that it can be applied for organisations and requires further modification if it is applied to the overall KSA AEC industry projects. Whereas, another said that "*To implement BIM in any organization, the first step is to create a community of practices*."

Also, to test the hypotheses, the interviewees reported that BIM implementation impacted by the six factors (raising awareness, perceived benefits of BIM, organizations capability, identifying barriers, removing the barriers, key factors influence the adoption), so that, the six hypotheses could be accepted. From all research steps, the suggested methodology for BIM implementation in KSA is set as shown in Figure 10.

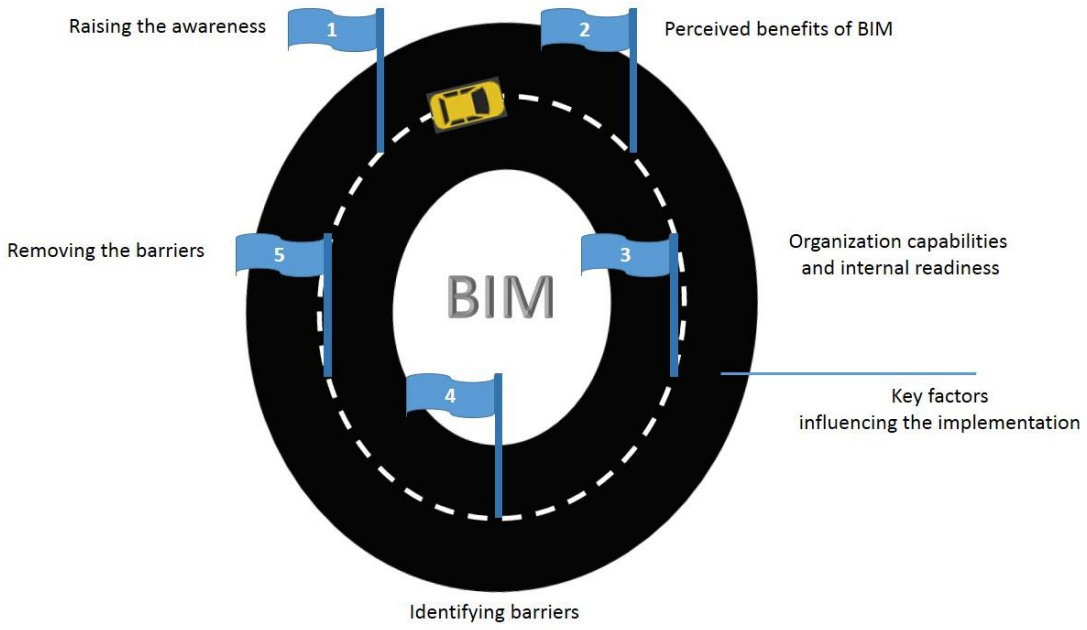

Figure 10: Final methodology for BIM implementation

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7: Conclusions

Currently, the attention of the construction industry is to eliminate waste and inefficiency to improve quality and profitability. However, BIM proved its competence in this way which motivated developed countries to use and mandate BIM. There are only limited examples of BIM implementation within the AEC Industry and AEC education in KSA.

This research proposed a model for BIM implementation in KSA to pave the way to facilitate using BIM, which in turn, increases the chances for creative and innovative solutions to the AEC industry issues, increases the quality, profitability and improves projects' performance and efficiency.

The key findings of this research are: exploring the main driving forces and the main external pressures pushing the implementation of BIM in the KSA AEC industry, identifying the main internal pushes, and proposed a methodology for BIM implementation in KSA AEC industry.

The questionnaire respondents and interviewees ordered the main external factors influencing the BIM implementations as; (1) Providing guidance on using BIM; (2) Government support and pressure for the implementation of BIM; (3) Providing education at university level; (4) Developing BIM and data exchange standards, rules and regulations; (5) Perceived benefits from BIM to client; (6) Collaboration with universities (research collaboration and curriculum designed for students); (7) Increased demand for BIM by other project parties; (8) Client pressure and demanding for the application of BIM in their projects; (9) Clients provide pilot project for BIM; (10) Contractual arrangements; (11) Promotion and awareness of BIM; (12) Competitive pressure; (13) Availability of appropriate software and hardware. This result is the same as the literature, but factors are ordered differently.

Unlike the literature, interviewees and questionnaire respondents in this study respectively ordered the internal push factors as; (1) Top management support; (2) Cultural change; (3) Perceived benefits from BIM; (4) BIM training program to staff; (5) Improving built output quality; (6) Continuous investment in BIM; (7) Desire for innovation with competitive advantages and differentiation in the market; (8) Technical competence of staff; (9) Financial resources of organization; (10) Improving the capacity to provide whole-life value to client; (11) Safety into the construction process (reduction of risk for accidents); (12) Collaboration among all project parties; (13) Projects complexity and profit declination. This result is in line with the literature, but the factors are ordered differently.

This study observed that failure to adopt the change to BIM would result in loss of competitive advantage and accordingly fewer chances to win new projects. Developing countries' governments must keep up with the development of the other developed countries which represent a pressure factor to mandate the latest technology like BIM. This pushes organisations to preserve themselves surviving and implementing BIM.

The suggested methodology consisted of six steps. The first is raising BIM awareness, the second step is to identify the perceived benefits for each party, studying the AEC industry readiness and the organizations capabilities, identify the barriers, propose strategic plans to remove those barriers, while the key factor for successful implementation is that each factor acts as a motivating factor and pushing the next one (not as just a separated step). The interviewees claimed that the methodology must be practical as a cyclical process, not a linear one.

The interviewees validated the proposed conceptual methodology and suggested the suitable order for its steps which in turn results in the final methodology for implementing BIM. The interviewees confirmed that, however, the main factor for rapid BIM implementation in KSA is the collaboration among different parties; the government, the organizations (client, designer, contractor, subcontractor, suppliers) and every project stakeholders, the main role is derived from the government as if the government mandates BIM, all parties will be committed to the change. The same way worked in advanced countries in mandating BIM.

This study recommends applying a mixed approach (top-down and bottom-up) to expedite and effectively implement the suggested methodology. Therefore, all AEC industry parties must collaborate and combine the efforts. The government of KSA can play a massive role to present convenient practical strategic plans for BIM implementation by providing a timeframe to mandate BIM as an obligatory requirement in the AEC industry projects. Also, the government could support the entities to overcome the barriers that hinder the BIM implementation. For instance, the government can aid entities to overcome the initial BIM implementation cost. Involvement of BIM in the AEC undergraduate and postgraduate syllabuses seems to be a premise in raising new generations fully oriented with BIM (long-term). Organizational decision makers have to support the staff, for example train the staff (short term), and put strategic plans in place to implement BIM. Every individual has to improve their BIM competencies.

Applying the suggested methodology could help to ensure the success of the BIM implementation, which in turn could improve the AEC industry performance and effectiveness, solve the project's issues, adapt creativity and innovation and create unexpected positive future for the AEC industry.

Suggestions for future research develop detailed, separate and special models for implementing BIM in KSA for each project party; client, architectural & designer, contractor, and subcontractor. Deriving models from the offered model in this research is to develop a short-term model and long-term model.

7.1 Limitations and assumptions of research

There is a difficulty to collect information for the construction industry in KSA due to the large area of 2,149,690 square kilometers involving different areas, each area having its own specific cultural nature. It was therefore not possible within the confines of the study to collect a large number of questionnaires or interviews from all the various areas around the whole country to provide an integrated image for construction industry in KSA.

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BIM Implementation Maturity Level and Proposed Approach for the Upgrade in Lithuania

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Abstract:

Recently, Building information modelling (BIM) proves its capability to solve the raised AEC industry issues. Therefore, several countries and entities pursue to transform into BIM especially the developed countries. Lithuania as a European country has a great challenge to cap up with the surrounding environment to implement BIM. This study aims to determine the BIM maturity levels in Lithuania and supposed the missed steps to upgrade to the next level. Eighteen important Lithuanian construction projects awarded the most successful implementing BIM are chosen as a case study. Face-to-face interviews were conducted with several BIM experts whose work at the chosen projects. The analysis conducted by the most effective theoretical model entitled BIM Maturity Matrix (BIMM). The key findings of this research that Lithuania reached the BIM implementing maturity level 2 while some projects still at level 1 that proves the ability of Lithuanian AEC industry to softly and completely transfer the maturity to level 2 by the recommendation provided through the proposed approach at the end of the paper. These results provide a stunning opportunity to improve the AEC project performance and reap the benefits of implementing BIM. Future studies can develop a framework to improve the BIM implementation in Lithuania softly.

Keywords: BIM; BIM maturity model; BIM stages; implementation maturity

1. Introduction:

The Architecture engineering construction (AEC) industry worldwide is facing a lot of challenges coming from the fragmentation of AEC and other technical, organizational and managerial problems of building projects (Ahmed, S., 2018). Since the Computer-Aided Design (CAD) was adopted by engineers, architectures, and designers during the late 20th century; an innovation and digitalization became a big title for the building industry (Ustinovichius, L., et al. 2017; Ahmed, S., et. al.., 2018). The complex analysis of problems revealed that BIM is the magic system to solve more than 70% of the AEC industry problems (Migilinskas, 2017). For example, the lack of interoperability that can highly be achieved by BIM implementation identified as the main cause for design conflicts and delay (Maya, R., et al. 2014). Translated into the innovative term, BIM is a shareable collection of building data, including a three-dimensional (3D) computer model of the entire project. This model includes data about each of the physical building elements that make up the project, including the location, number,

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and size of those elements. This fact makes of the building information models a shared knowledge resources to support decision-making about a facility from planning to demolition, it is the present and the future of the construction sector (Di Giuda et al. 2015; Zhao, X., 2017). The BIM model allows to analyze the current situation, solve the problems with information management using team-based collaboration between project participants and integrated project delivery, establish Common Data Environment, and initiate use BIM-based procurement (Ustinovichius, L., et al. 2017).

Nowadays many countries across the world are in different stages of implementing BIM and adopting it into their legislation. A lot of efforts have been made by researchers and practitioners to set the BIM implementation criteria. Therefore, authors have reviewed and relied on these works as a tool to analyze the steps taken in Lithuania with a view to arriving at an appropriate model for the systematic development of BIM for better and faster development. The United States has long been a global leader in BIM development and implementation in the construction industry, while the US General Services Administration has pioneered the implementation of BIM on public projects (Smith, P., 2014).

In the other side in the United Kingdom, the government in 2011 has introduced a BIM implementation strategy for the UK construction industry. The objective was to transform the UK industry into a global BIM leader (HM Government, 2012). The Scandinavian region is also a global leader in BIM adaptation and implementation. Norway, Denmark, and Finland embraced the ArchiCAD software early and were amongst the first countries to adopt model-based design (Smith, P., 2014). The Finnish public sector is the main driver in BIM adaptation with Senate Properties Company, which is a major government entity responsible for managing the country's property assets. The Danish government is a strong supporter of BIM and invests heavily in research and development. In Norway, BIM implementation is led by Statsbygg - a firm responsible for the construction, management, and development of government facilities (Smith, P., 2014). However, the application of BIM is still rare at the initial planning stage (Rafiee, A., et al., 2014). In the Czech Republic, There are still some barriers for BIM implementation: the readiness of BIM (BIM is not prepared well enough for widespread implementation), high training costs (education requirements are unknown and the learning curve is steep), investment in new technology, hardware and software is needed. All this makes BIM learning difficult to achieve (Bouška, R., 2016).

In the other hand, (Novakova, V., et al. 2018) found that if the current trend is not reversed as soon as possible, the Czech Republic will become less competitive in the global economy and dependent on foreign knowledge and technology. BIM practice offers to redefine the conditions of production of technical projects in order to save expended resources and increase productivity (Metallinos, P., Pantouvakis, J., 2018). Whatever, several studies have confirmed that individual efforts by people are insufficient to have the best value from BIM implementation, there is a need for complementary methodologies as people-oriented systems, data-driven approaches, and process innovation. (Khosrowshahi, F., Arayici, Y., 2012). Also, BIM implementation in design firms generally faces the lack of clarity in the adoption process, and there is a need for providing specific support services to firms who implement BIM (Shaban, M. & Elhendawi, A, 2018, Hochscheid, E., Halin, G., 2019). As the aim of the research is to identify needed next steps to systematic growth of BIM implementation for better and faster results to become more competitive in the global economy. Maturity models were investigated in order to be used as a scale to measure implemented steps at BIM implementation in Lithuania. Maturity refers to the aspects of BIM ability or quality of use and the features or fields for BIM implementation (Chen, L., et al., 2014). (Yusof, N., et al., 2018) adopted a bibliometric analysis

to identify the trends of BIM maturity studies, its models, and indicators for assessing BIM maturity. According to her systematic review, the most productive author of BIM maturity is (Succar, B., 2009b), who published four articles and had highly cited with 335 citations. (Succar, B., 2009b) introduced a comprehensive BIM maturity that consists of BIM capability, BIM stages, BIM competency sets and a roadmap to achieve the main goal of BIM implementation; integrated project delivery (Ahmed, S., et, al. 2018).

Also (Smits W., et al., 2017) analyzed the impact of the BIM implementation on the performance of construction companies in the Netherlands by using the BIM maturity assessment. Their study showed that the existence of BIM planning team is very important to improve the company's project performance. Also, (Azzouz, A., Hill, P., 2017) used Building Information Modelling Maturity (BIMM) to identify the best practices of BIM in 1291 construction projects. BIM is considered as a part of industry 4.0 (Oesterreich, D, T., Teuteberg, F., 2016). In spite of this, (Latiffi, A., et al., 2014) said: most of the construction players in developing countries have not yet implemented BIM, and they mostly concentrated BIM projects in public megaprojects. For this, only models that consider pre-BIM maturities such as NBIMS-CMM, BIMM and the BIM Proficiency Index are suitable for assessing BIM implementation in these countries.

From another side, (Wu, C., et al., 2017) comprehensively reviewed nine of the most typical BIM maturity measurement tools. Although he found that the NBIMS CMM tool was in the first class of assessment because of its Structure which is the simplest among all tools, it had limited scope to BIM technical aspects. The second place was IU BIM Proficiency Index with a simple structure; Easy to implement. but all measures have the same weight, no distinction; also, limited scope to BIM technical aspects; Low flexibility; Lacks field tests, empirical studies and practical BIM MM which coming in the third place was the highly flexible tool selected for BIM users that plan to implement or improve BIM implementations. BIM MM is adjustable for different users' aims. Covers multiple aspects of BIM; Easy to implement; Explains detailed the matching between BIM and organizational strategies. Whatever this method still has lacked field tests, empirical studies and practical and data collections for validation and optimization; authors had one experience with it through (S., Ahmed, 2018) and found it easy to use and can be familiar with the BIM team in a new transforming companies towards BIM. Accordingly, BIM maturity model was chosen as a tool to guide through the systematic implementation of BIM.

BIM Maturity Indicators:

BIMM is a knowledge tool for identifying the current BIM Maturity of the organization or project team and provided criteria in three BIM fields (Technologies, Processes, and Policies). The ability of the construction stockholders to operate and exchange information can be assessed by using BIM maturity model which will describe maturity level at the certain project. The prerequisites were defined as trough BIM steps that identify necessary activities, services, and products to meet requirements. Maturity assessment will help to define the implemented steps consequently this will help to define the roadmap for systematic improvement for implementation by knowing the remained not implemented activities.

Authors differed in identifying BIM maturity indicators, where various indicators were proposed due to the multidimensional of BIM usage. BIM maturity indicators facilitate the assessment of projects, companies, and industry implementing of BIM and how to improve the progressing. Although of the

difference, all of them has four essential indicators Technology, Process, and Policy or Protocol, and People. Some of them have five indicators and others put more details and reached to eleven one. Anyway, BIM Technology appears in (general BIM technology, software, visualization tools) and BIM Users (competencies, attitudes, motivation, training, and satisfaction) (Wu, C., et al., 2017), the BIM Process consists of two types of interactions: human to human and human to computer. Including workflow, life cycle process. While the organization measures the organizational support, leadership commitment, BIM culture and strategies (Wu, C., et al., 2017). However, BIM output measures the project's performance (cost reduction, speedy completion, improvement of sustainability and functionality, standard) and the life cycles of the facilities (the actual cost of investment, return on investment, ability to deliver on time, stakeholder satisfaction, and ease of use (Abdirad, H., 2017). The BIM performing in the industry represents by growth in BIM implementation, investment, BIM training, and knowledge are some examples of indicators for BIM output (Abdirad, H., 2017). Although of all efforts, clearly still more work is needed to confirm if these BIM maturity models can assess the BIM implementation.

(Chen, P.-H., Nguyen, T., C., 2017) tested three indicators Technology, Process, and Information using structural equation modeling on BIM projects and identified that Process is the most important indicator for evaluating BIM maturity. (Yosuf, N., et al. 2018) shows that the majority of the authors identified Technology and Process as the first top indicators for measuring BIM maturity, followed by Information, People and Policy. Specifically, there is a dearth of studies from the developing world and that focus on People, Policy, Organizational, and BIM output indicators. (Succar, B., 2009) considered one of the most internationally known and most comprehensive models of maturity. According to (Succar, B., 2009) BIM maturity assessment includes TPP (technology, process, and policy) components and it is subdivided into three stages as sown in Figure 1 which are:

BIM Stage 1: Object-based modeling BIM implementation is initiated through the deployment of an ‘object-based 3D parametric software tool' similar to ArchiCAD, Revit, Digital Project and Tekla within the three Project Lifecycle Phases. At stage 1 visualization is emphasized through automated generation and coordination of 2Ddocumentation and 3D visualization. Also, basic data exports will be delivered as (ex: door schedule, concrete quantities, FFE costs) and light-weight 3D models (ex: 3D, DWF, 3D PDF, NWD, etc…). Collaboration at Stage 1 is similar to pre-BIM Status and model-based interchanges between different disciplines are not significant as it is limited to not systematic Data exchanges and communication between project stakeholders.

BIM Stage 2: Stage 2 players use many technological ways to do a model-based collaboration with other disciplinary players. The model-based collaboration includes the interoperable exchange of models or part-models through ‘proprietary’ formats (ex: between Revit, Architecture and Revit Structure through the RVT file format and non-proprietary formats (ex: between ArchiCAD and Tekla using the IFC file format which may be extended through Lifecycle Phases. Generation of 4D (time analysis) and 5D (cost estimating) studies is the very valuable output of this stage.

BIM Stage 3: Model server technologies (using proprietary ,open or non-proprietary formats) are used in order to rich integration of models which are created ,shared and maintained collaboratively across Project Lifecycle Phases. Analysis of interdisciplinary models can be implemented at the early stages of virtual design and construction.

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Status of AEC industry before the implementation of BIM (manual, 2D or 3D CAD)
PRE-BIM
BIM Stage 1: object-based MODELLING
1
BIM Stage 2: model-based COLLABORATION
2
(Succar, 2008)
BIM Stage 3: network-based INTEGRATION
3
Integrated Project Delivery, the long-term goal of BIM implementation
IPD

Fig. 1. BIM fields (Succar, 2009)

2. Research Methodology:

An extensive investigation for the literature was conducted to determine the most effective tools for measuring the BIM implementation maturity levels. Every tool has its indicators in each stage. As a result of the literature review, the most effective and appropriate tool is BIM Maturity Matrix "BIMMM" (the theoretical model of (Succar, B., 2009)) which is considered (according to the previous studies) one of the most internationally known models of maturity. It helps to define the necessary steps for improving the BIM implementation according to competency criteria, and in a very flexible way. Evaluation analysis of maturity of BIM Implementation was conducted based on the characteristics of BIM implementation in a sample contains 18 projects of important Lithuanian construction projects which were awarded a national award for BIM implementation in Lithuania. Empirical research was done to survey the implemented steps at the projects in addition to surveying local policies regarding BIM in Lithuania to check the maturity stage at all of the technology, processes, and policy fields of BIM implementation. Face-to-face interviews were conducted with some experts in the field of BIM whose work at the companies that participated in the research. The interviews were conducted in a semi-structured manner with the aim of taking individual information and also intersecting the views later. The interviews results developed the data obtained in the research. The result of comparative analysis using BIM maturity model and best international practices results were used to suggest a systematic approach for BIM implementation in Lithuania that enhances the recent practices and guides the main players at construction projects.

3. Results and discussions:

Assessment of BIM implementation maturity stages in Lithuania:

Technology field

According to Succar model technology field includes three technology step type to meet the requirements of BIM stages which are: software, hardware, and network (Succar, 2009). And according to each sub-requirement for each step we classified the BIM maturity implementation in Lithuania for 18 studied projects, the assessment was according to of used software only due to the limitation of data availability for the other two technology type which is also can be considered secondary factors and supportive tools for software's implementation. The first 3D modeling experiment implemented in Lithuania in 2002- an office building in Klaipeda, the building design was introduced with the 3D static analysis and BIM technologies. The table 1 shows the implemented software's at the studied projects and we classified the maturity of BIM implementation level at projects according to the used software as per three common level stages of BIM implementation. Most of the studied projects were the sample that awarded at national BIM implementation award in Lithuania. The result was that 2 of studied projects at level 1(Modeling) and 15 was at level 2 (collaboration) and only 1 was at level 3 (integration). we can see that 88 % of studied projects are at level 2 or 3 which show medium maturity level for BIM implementation at studied projects in scope of software's. At the modeling and visualization and engineering analysis level there was plenty of used software's like, structural BIM model, Revit 2016, RIB iTwo 2015, Bentley Pro Structures V8i Power Product, Tekla Structures, Revit

MEP, Intergraph Visual Design VVD. Also at clash detection, project costing, and collaboration there was specialized software's like 3D simulation in real time (4D), estimation automatically using 5D BIM model principles Tekla BIMsight, Solibri Model Checker/Viewer for communication, Autodesk Navisworks Manage for primary selection and crossing analysis, Design quality control, IFC model, native software format "rvt", Sharepoint-based Collaborative Data Environment (CDE), based on the PAS1192-2 standard. In conclusion, most of the software's steps were met in studied projects but three important steps for next technological improvements would be recommended are the automation of national code checking and compliance evaluation, use of more efficient CDE environment and implementation of a classification system based on ISO12006 and ISO81346 standards within all construction entities types.

Table 1 shows the implemented software's and its maturity level at the studied projects

SN.	Project	trade	BIM tools systems	Maturity level
1	Office building in Klaipėda, 2002	Building	-3D static analysis and BIM technologies	1-Modelling
2	Vilnius Municipality (2003–2006)	Building	-structural BIM model -database (6D) model prototype	2- collaboration
3	MG Victoria administrative (2004–2005)	Building	-3D simulation in real time (4D). -estimation automatically using 5D BIM model principles.	2-collaboration
4	Beržų terasos“ in Vilniuje (2013–2014)	Building	-3 D model high-quality project delivery plans	1-Modelling
5	New Riviera	Building	Revit 2016, RIB iTwo 2015	2-collaboration
6	installation of the co-generation biofuel boiler house, in Kaunas	industrial	• Architectural part: Autodesk REVIT, Build:16.0.490.0 20150717_1515(x64) • Building structures part: Tekla Structures, 20.1 version • Design part (Technology Tying): Bentley ProStructures V8i PowerProduct, version 08.11.11.616 Bentley STAAD.Pro V8i, version 20.07.11.45 Autodesk REVIT, Build:16.0.490.0 20150717_1515(x64) • Heat production and supply part: Bentley OpenPlant Modeler V8i, version 08.11.09.568 Bentley AutoPIPE V8i, version 09.06.02.06 • Technological equipment design: Solidworks 2015 x64 Edition Intergraph Visual Design VVD, version 16.0 Danish Exergy Technology A/S, version EN12953 ver.1.0	2-collaboration
7	Joint Centre for Life Sciences in Sauletekio avenue	public buildings	• Architectural model: AutoCAD Architectural • Structural model: TEKLA Structures	2-collaboration

			• Engineering systems: DDS-CAD, MagiCAD, Revit MEP, Autocad MEP • Communication and visualization: Tekla BIMsight	
8	crossroad reconstruction in Jakai	transport infrastructure	• Autodesk AutoCAD Civil 3D • GeoMap • PTV VISSIM • Bentley Microstation • Ansys • Autodesk 3Ds MAX Design	2-collaboration
9	Gullfaks administrative building	administrative building BIM project abroad	• Autodesk Revit – facade element modeling and etc. • Solibri Model Checker/Viewer – for communication • Autodesk Navisworks Manage – for primary selection and crossing analysis • Autodesk Robot Structural Analysis – for wind load analysis • SolidWorks / Autodesk Inventor – • bearing parts design and analysis; additional production drawings preparation • Autodesk AutoCAD – for detailed joints	2-collaboration 2-collaboration
10	Apartment houses in Karaliaučiaus 7b street		• BIM model • virtual reality tour	2-collaboration
11	public buildings BIM project	public buildings	• Design quality control • calculation of quantities • simulation of the project made in 5D • supervision developed using the BIM model	2-collaboration
12	Tunnel overpass on A2 road	transport infrastructure	• Revit Central File • Civil3D program • Dynamo environment	2-collaboration
13	Clarion Hotel Helsinki, Helsinki Tower	public buildings	• Tekla Structures program. • IFC model Project parts coordination was performed by HENT AS using Solibri model checker software.	2-collaboration
14	shopping center "Žali" in Vilnius	public buildings	• geometric detail level from LOD 350 to LOD 500 The purpose of using BIM in the project is to create the most accurate and detailed model for construction, then transforming it for facilities management objectives.	2- collaboration
15	„Baltas lapas	Residential houses	• "cloud" environment using the “BIM360 team” tool. • native software format "rvt". an internal classification has been created, which facilitated the generation and structuring of quantities • “Revit Live” tool has also been used to monitor the complex design of the car park and the location of engineering networks in heavily restricted areas in the VR	3-integration

16	Business center in Kaunas	public buildings	• The information was exchanged in a single .ifc format by storing it in a Dropbox accessible to everyone • Project participants provided information, reviewed, and correlated issues with Tekla BimSight software	2-collaboration
17	Warehouse in Kaunas	Industrial Buildings	• BIM protocol was prepared and agreed with the customer with the level of detail of the project • Sharepoint-based Collaborative Data Environment (CDE), based on the PAS1192-2 standard, has also been developed to share, review, approve and assign information to the customer • The 3D integrated model was loaded with a true terrain of the current location with precise road layout and created a virtual reality that helped the customer to determine the visibility of the building from side to side using VR glasses.	2-collaboration
18	ICON Växjö Complex in Sweden	best BIM project abroad	In "Clouds" was exchanged with IFC format data, using all the same coordinate system for all project participants. • design of the building frame, which was developed using Tekla software	2-collaboration

Processes field:

Process step type includes leadership, infrastructure, human resources, products &services (Succar, B., 2009). Some initiatives were found at studied projects at leadership field certainly at management decisions and communication activities as in project NO 15 the "cloud" environment using the “BIM360 team” tool was used and at project NO 16 The information was exchanged in a single IFC format by storing it in a Dropbox accessible to everyone. Solibri Model Checker/Viewer – for communication was used at project NO 9 and NO 13 and Tekla BIM sight was used at project NO 7 for communication. At Project NO 18 also the coordinate system was used for all project participants. Also there were some steps regarding products and services, in term of products there was some structured outputs which extended to virtual components like project NO 15 as “Revit Live” tool has also been used to monitor the complex design of the car park and the location of engineering networks in heavily restricted areas in the VR, also at project 17 The 3D integrated model was loaded with a true terrain of the current location with precise road layout and created a virtual reality that helped the customer to determine the visibility of the building from side to side using VR glasses. We couldn't assess steps about infrastructure and human resources due to data limitation. Therefore we found that important steps were taken in the process field towards communication and better emphasize is needed in the scope of products and services.

Policy field:

It includes contractual, regulatory, and preparatory steps (Succar, B., 2009). At contractual scope one attempt was found regarding of responsibilities at project NO 17 as BIM protocol was prepared and agreed with the customer with the level of detail of the project at Sharepoint-based Collaborative Data

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Environment (CDE), based on the PAS1192-2 standard, has also been developed to share, review, approve and assign information to the customer. In contrast, important steps were found at the contractual scope in rewards by establishing The annual competition "Lithuanian BIM projects" started at 2016 dedicated to select the best Lithuanian company practices using building information modeling (BIM) technology and methodology. The best projects were selected in the following categories (Lithuanian BIM project, 2016):

1. BIM in residential buildings;
2. BIM in public buildings;
3. BIM in industrial buildings;
4. BIM infrastructure (communication infrastructure);
5. BIM in infrastructure. Other engineering structures;
6. BIM project abroad.

Table 2 includes the reward criteria and Table 3 shows the projects scores for the 2018 competition.

Table 2: Reward criteria for BIM implementation in Lithuania

SN	**BIM implementation reward criteria**	**Range**	**New at 2018**	**OLD from 2016**
			Max. Criteria weights	Max. Criteria weights
1	BIM solutions for the better design solutions. Outstanding usage of BIM in resolving design challenges such as:			
1.1.	Identification of the customer's expectations (customer requirements)	from 0 to 2	2	1
1.2.	Current situation conditions modelling	from 0 to 1	1	1
1.3.	Design in the early stages of decision-making;	from 0 to 1	1	1
1.4.	Modeling of the complex architectural geometry forms;	from 0 to 2	2	1
1.5.	Decisions of irreconcilable design solutions and engineering systems	from 0 to 1	1	1
1.6.	Construction technologies solutions and material selection;	from 0 to 1	1	1
2	BIM for the green building and sustainability (Green and sustainable). Design Judgment will be made on the outstanding usage of BIM in sustainable design considerations, such as:			
2.1.	Environmental impact assessment;	from 0 to 1	1	1
2.2.	Selection of engineering systems;	from 0 to 1	1	1
2.3.	The energy efficiency assessment;	from 0 to 1	1	1
2.4.	Life Cycle Assessment;	from 0 to 2	2	1
3	BIM innovation (Innovative use of the information in BIM). Innovation is called change compared with the normal market activity			
3.1.	Design phases (different calculations, simulations, decision support systems for technologies variants selection and etc)	from 0 to 2	2	1
3.2.	Construction planning and management inovations;	from 0 to 1	1	1

3.3.	Quality Assurance; (A. Different quality assurance software used at any of separate stage (at least 0.5 points); At design and construction stage (plus up to 0.5); At design, construction and FM stages (plus 1) B. Using the classification system (at least 0.5). Formula A+B should be applied.	from 0 to 1	2	1
4	Changes in the communication process. Used standards, methodologies (Business Collaboration transformation). Outstanding usage of BIM for enhancing standards and workflows in:			
4.1.	At the design phase; (Use of Use Cases, LOD, LOI, Development of BEP, Standards used)	from 0 to 2	2	1
4.2.	The information exchange between the various disciplines (CDE used. File or WEB server-based communication infrastructure used)	from 0 to 2	2	1
4.3.	Construction planning between gen. contractor and subcontractors;	from 0 to 1	1	1
4.4.	Coordination of As-built model development together with customer team	from 0 to 1	1	1
4.5.	Model customization for operational stage and asset management	from 0 to 2	2	2
4.6.	Building lifecycle data collection at the facility management stage (use of different sensors for monitoring	from 0 to 2	2	1
	Overall maximum available points:		28	

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Table 3: projects scores for 2018 BIM implementation award.

BIM construction project number	BIM awards evaluation value
Dwellings 1	9.9
Dwellings 2	6.5
Dwellings 3	7.1
Dwellings 4	5.1
Dwellings 5	5.1
LT_BIM_Projects abbroad1	8.9
LT_BIM_Projects abbroad2	11.9
LT_BIM_Projects abbroad3	13.5
LT_BIM_Projects abbroad4	11.9
Public1: Office	12.1
Public2: Office	10.8
Public3: Office	12.8
Public4: Shopping center with the administration	5.9
Public5: Office	4.9
Public6: Office	3.7
Public7. Special services	4.4
Public8: Office	5.8
Public9: Shopping center	19.4

The criteria of the award included four main scopes that reflect results of BIM practices maturity as following:

1- BIM solutions for better design solutions
2- BIM for the green building and sustainability
3- BIM innovation (Innovative use of the information in BIM)
4- Changes in the communication process

Table 2 reward criteria and Table 3 shows the projects scores for the 2018 competition. The scores ranged between 3.7 and 19.4 out of 28 max points, and this reflects medium maturity level which was founded during assessing maturity at technology field and process field.

Requirements, more emphasis should be put on these criteria to encourage companies to develop BIM implementation in a systematic way.

No initiatives were found in contractual steps regarding risk allocation and insurance.

Regarding national level initiatives Public institution “Skaitmenine statyba” (“Digital Construction”) was founded which are an organization that joins associations of the Lithuanian construction sector and coordinates the digitalization process of Lithuanian construction (Official Lithuanian Digital Construction, 2018).

The Digital Construction institution was founded on March 5, 2014, by 13 associations:

- Lithuanian Builders Association
- Lithuanian Roads Association
- Lithuanian Association of Consulting Companies
- Lithuanian Architects Chamber
- Lithuanian Association of Civil Engineers
- Lithuanian Electricity Association
- Lithuanian Association of Land Reclamation Enterprises
- National Passive Hous Association
- Project Expertise and Fire Safety Companies Association
- Association of Buildings Certification Experts
- Building Product Testing Laboratory Association
- "Structural engineers club"
- Lithuanian EPS Association

And it became in 2015 y. as associate member joined World Alliance "BuildingSMART Nordic chapter. From 2018 is the member of bSNORDIC.

Main directions:

- BIM (Building Information Modeling) methodology development and implementation in Lithuania (EIR, BEP, LOD (LOIN), BIM Stages and Use Cases and etc. templates);
- Implementation of BSI Industry developments: Foundation Classes (IFC); BCF, IDM, bSDD and etc.
- National Construction Classification system development and implementation;
- Organization of International Annual Digital Construction and BIM Regional developments Conferences (from 2012) (Digital Construction, 2018.)
- Organization of BIM Awards Competitions;
- BIM competencies model development, training organization, and certification;

Till the 2018 year no systematic steps were found in the scope of building regulations as codes and standards, also on project guidelines no steps were founded regarding projects benchmarks and best practices and classification in Lithuania. Regarding preparatory steps at the scope of research many conferences and events were held as follows:

From 2012 y. Lithuanian Builders Association arranging conferences in a BIM field called "Digital construction".

From 2014 y. till 2019 Public institution "Skaitmenine statyba" ("Digital Construction") with partners in Vilnius arranging annual international conferences in a BIM field called "Digital construction".

The most important event of the year for "Digital Construction" is an essential part of RESTA – the annual expo of construction.

In the scope of education at the beginning of 2015 new academic year, Vilnius Gediminas Technical University, Faculty of Civil Engineering introduced the first Master's degree program in Lithuania "Building Information Modeling", which is preparing BIM experts. From 2018 already within most of Vilnius Gediminas Technical University construction related bachelors programs were implemented BIM modules. Lithuania still does not have a BIM standard, national construction classification, and

universal data exchange standard IFC. In Lithuania, the information about building developed using BIM method usually remains with designers. Lithuanian BIM experts say the created information transmission to the customer is a matter of agreement. When transmitting only the information that is regulated by Lithuanian Law on Construction (2017). Within 2016 and 2019 BIM awards experience the majority of design and construction companies are already beginning to apply BIM in the design or construction stages separately. However, 2018 and 2019 experience shows that Lithuania already has few projects (within Shopping center, Industry building, and Offices categorize) were BIM methodology was used from design to construction and preparation for facility management use. And the maturity level of presented projects growing every year.

Suggested approach for systematic growth of BIM implementation:

According to BIM maturity assessment for BIM implementation on best projects in Lithuania, authors found that there is a good use of BIM at level 1 and 2 with a scarcity use of BIM level 3. Plenty of steps at policy and process fields were implemented, but the full integration of services during the project life cycle is still under implementation. Therefore, the needed steps for systematic BIM implementation defined depending on BIM maturity assessment and best international practices literature review results. For technological improvements would be recommended automation of national code checking and compliance evaluation, use of more efficient CDE environment and implementation of a classification system based on ISO12006 and ISO81346 standards within all construction entities types. Therefore more efforts should be done on promoting awareness about BLM (building lifecycle management) in order to achieve fully integrated project delivery which offers better interoperability using international standards about elements coding for better standardization which will allow e-checking for conformance of products. Also at the process field better emphasize is needed in the scope of products and services clearer definition we need to have about outputs and modes of delivery taking into consideration contractual conditions about responsibilities and property rights. The practices at policy field also missed the regulatory field as till the 2018 year no systematic steps were found in scope of building regulations as codes and standards, also on project guidelines no steps were founded regarding projects benchmarks and best practices and classification, therefore government with researchers need to start to develop BIM standard, and national construction classification and universal data exchange standard IFC which will allow to develop national implementation policy that includes best practices and benchmarks that rely on international capability models.

Therefore, the detailed strategic and operational methodology should be developed to support the systematic improvement of BIM implementation by Lithuanian companies that include Lithuanian BIM standards with better effort and more details about not yet implemented steps which we identified in this study certainly at the field of polices which was less mature among three BIM implementation fields. Figure 2 describes the suggested next steps:

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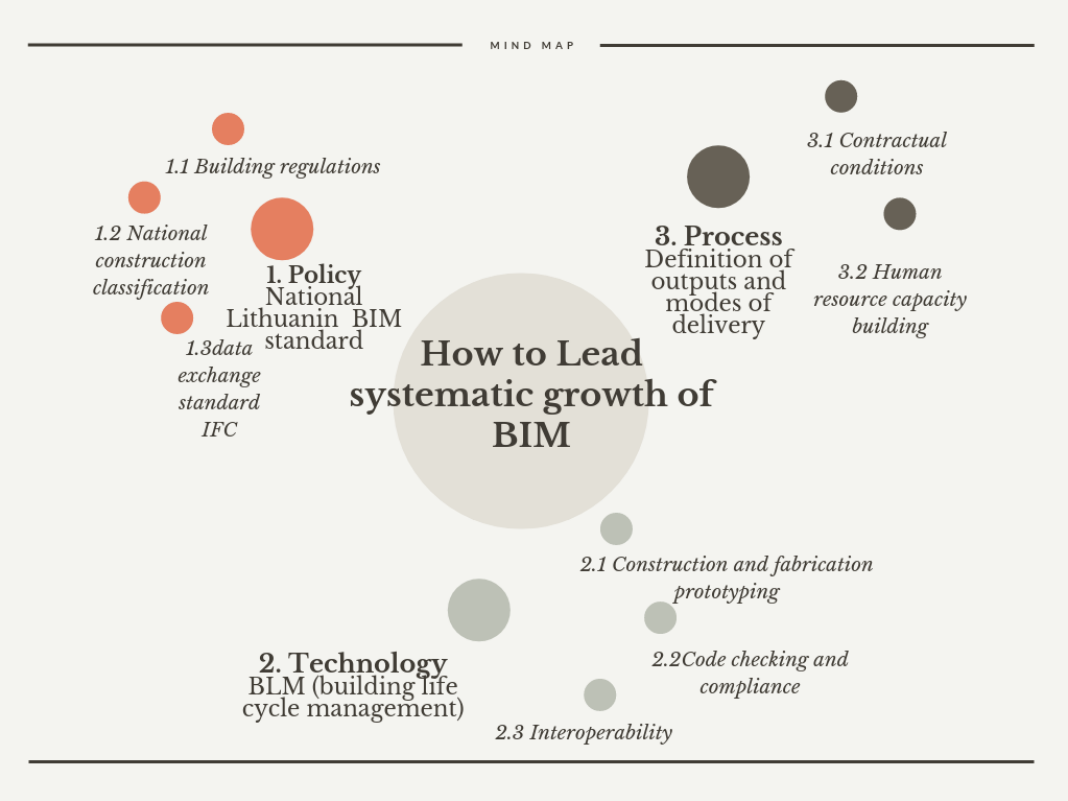

Fig. 2. Needed next steps at the developed strategic and operational methodology. (Authors, 2019)

4. Conclusions:

The authors of the article presented the BIM approach and analysis of BIM implementation maturity of construction projects in Lithuania. Evaluation analysis of maturity of BIM implementation was conducted based on the theoretical model of (Succar, B., 2009). In order to assess the maturity of BIM implementation in Lithuania empirical research was done to survey the implemented steps of 18 projects to check the maturity stage at all of the technology, processes, and policy fields of BIM implementation. It can be said that the level of implementation of the BIM is more than good in a country such as Lithuania; the BIM has not been officially adopted until the date of this paper. The authors found that 15 of the best 18 projects in Lithuania were implemented in accordance with the second level of BIM according to the evaluation tool used in this paper BIMM. In addition, at least one project was implemented according to the third level. This gives an optimistic view of the reality of the BIM in Lithuania in the next few years. Anyway, the result of comparative analysis using BIM maturity model and best international practices results were used to suggest a systematic approach for BIM implementation in Lithuania that enhances the recent practices and guides the main players at construction projects. The researchers made several recommendations for each of the fields assessed - including, but not limited to, in the field of technology. The building companies need to move to a general state of automation and use international standards within all construction entities. In the field of operations, a better understanding of delivery methods is required. In the field of policy, which is the least mature among the three areas, the authors believe that the Government should begin to develop standards for BIM, develop a national implementation policy that includes capacity building and best practice, and support the systematic improvement of BIM implementation.

Authors couldn't assess steps about infrastructure and human resources, and some technology types due to data limitation.

Furthermore, no systematic steps were found in the scope of building regulations as codes and standards, moreover, on project guidelines, no steps were founded regarding projects benchmarks and best practices and classification in Lithuania.

The future studies may be dealing with a framework to enhance the BIM implementation in Lithuania.

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